Nov. 16, 1954 K. W. WILCKENS 2,694,789

DELAYED-ACTION MAGNETIC CIRCUIT BREAKER

Filed Dec. 7, 1950

Fig. 1.

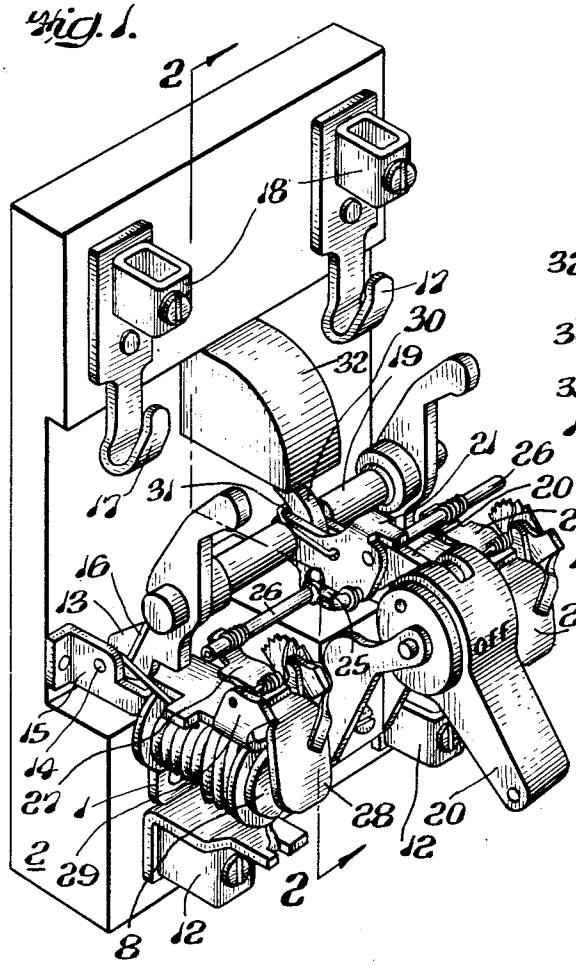


Fig. 3.

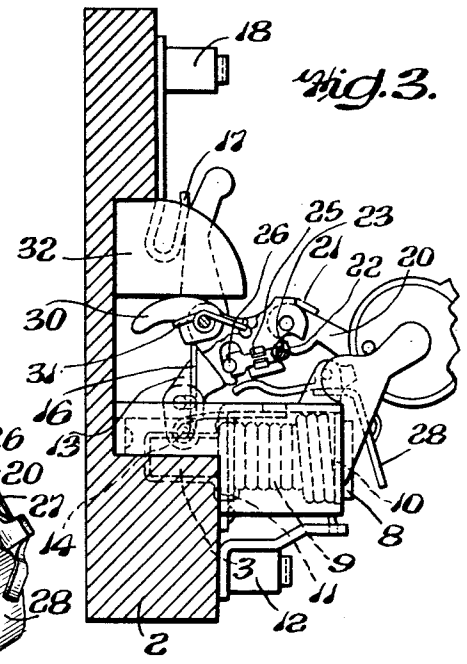


Fig. 2.

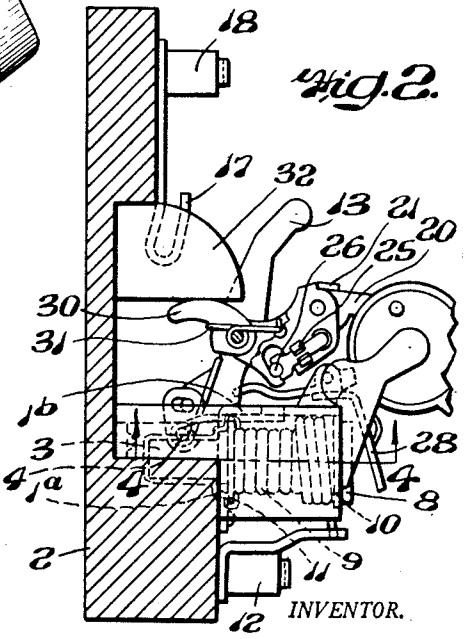
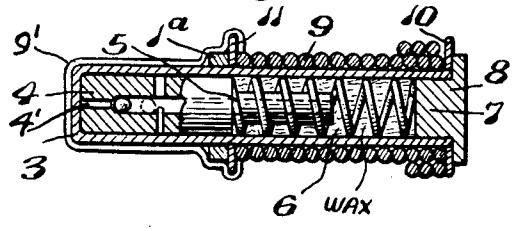


Fig. 4.



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DELAYED-ACTION MAGNETIC CIRCUIT BREAKER

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Application December 7, 1950, Serial No. 199,596

7 Claims. (Cl. 317—179)

My invention is an improved, trip-free, electromagnetic circuit breaker which will permit the flow of a wide variety of current overloads so long as the temperature resulting from such overloads is harmless to the insulation to be protected, but which will promptly trip on excessive overload in the event of an increase in temperature which is detrimental to the insulation to be protected and will be immediately ready for reclosure if the abnormal condition has ceased but will again trip if such abnormal condition persists.

My improvements are primarily designed to render circuit breakers of the general type shown in my patent, No. 2,360,922, more suitable for use in the protection of oil-immersed transformers in which there is a high rate of heat transfer from the core and conductors to the oil and in which it is desirable to maintain the transformer in operation notwithstanding a reasonable percentage of overload for a much longer period than can be secured by usual types of delayed action circuit breakers.

The tripping of delayed action magnetic circuit breakers in response to overload is normally controlled by the longitudinal movement of a magnetically permeable core within a solenoid coil into position to augment the magnetic pull of a pole on a tripping armature complementary to the pole. Such core must be at all times partly within the magnetic field of the coil and the pull of the magnetic field on the core under normal or slight overload conditions is neutralized by a retarding coiled spring of sufficient strength to substantially prevent movement of the core on the flow of current up to a desired amount, say, 125% of rated current. The movement of the core into the coil and toward the pole under heavier overload conditions is retarded, but not prevented, by the enclosure of the core and spring in a liquid-containing tube or dash pot. The core may contain a valve-containing bore or make a sufficiently loose fit with a tube to permit the slow escape of liquid from the front to the rear of the tube so as to retard the advance of the core toward the pole proportionately to the degree of overload, viz., the greater the overload the more rapid will be the movement of the core toward the pole and vice versa. However, even a slight overload above the predetermined minimum will eventually cause the movement of the core into contact with the pole and the actuation of the tripping armature. Moreover, a slight overload will gradually bring the core to a position where the occurrence of a heavier overload will trip the breaker in much less time than would be required if the core were in its datum position at the beginning of such heavier overload.

In accordance with my invention, the movement of the core on overload always begins from the datum position and only begins after an ambient temperature has been reached indicative of an injurious temperature in the equipment protected or the magnetic coil of the breaker has become excessively overheated. The rate of movement of the core after being released is proportional to the degree of overload, so that the delay in tripping of the breaker may be proportioned to the degree of overload prevailing after harmful temperature conditions prevail. Upon the interruption of the circuit by the breaker, the spring immediately returns the core to its datum position so as to permit the reclosure of the breaker and its maintenance in closed position if the overload has fallen below the predetermined minimum and without awaiting a fall in temperature.

I accomplish these objects by filling the tube between the core and the pole with a thermotropic, non-magnetic

substance of sharp melting point, and preferably of lower specific gravity than the core and which, when solid, prevents the longitudinal movement of the core, and which passes directly from the solid (crystalline) state to the liquid state upon attaining its critical temperature. This conversion of the thermotropic solid into a liquid, preferably of low viscosity, permits the magnetic field generated by an overload in excess of the predetermined minimum to draw the core through the liquid, which seeps behind the core. When the core has been advanced sufficiently to cause the armature to trip the circuit breaker, the spring returns the core to its datum position and the liquid returns to place between the core and pole, where it again solidifies as soon as its temperature drops below the critical melting point.

I have found hard waxes, and particularly pure paraffin hydrocarbon waxes, having a melting point above normal atmospheric temperatures and a high boiling point are particularly suitable for use as the thermotropic substance under ordinary conditions since they pass directly from a rigid, solid state to a liquid state without passing through an appreciable plastic state. The particular wax, or other thermally liquefiable substance, used will be dependent on the type and strength of the insulation to be protected and the range of ambient temperature conditions and consequently on the temperature at which it is desired to permit movement of the core. For example, under varying, but ordinary, conditions, I may use n-eicosane ($C_{20}H_{42}$) which has a melting point of 36.7° C.; or n-tetracosane ($C_{24}H_{50}$) which has a melting point of 49.4° C.; or n-triacontane ($C_{30}H_{62}$) which has a melting point of 64.7° C. Until such waxes have reached their melting point they effectively prevent the movement of the core toward the pole, and when they have melted they permit movement of the core responsively to the magnetic field but subject to retardation by the dash pot action of the liquid in the tube. Since the range of temperature conditions under which such breakers are used varies from far below 0° C. to far above 100° C., it will be understood that a wide variety of sharp melting point substances may be required, as, for instance, metals of relatively low melting point, but it is desirable to avoid substances which form plastics between the solid and liquid states, as such plastics may permit the partial advance of the core and prevent its return to datum position upon the cessation of abnormal conditions in the circuit. The suitability of a thermotropic substance is usually indicated by the shortness of its range of melting temperatures, which generally should not exceed 1° C. to 2° C.

The principles of my invention and the best mode in which I have contemplated putting such principles into practice will further appear from the following description and the accompanying drawings in illustration thereof.

In the drawings, Fig. 1 is a perspective view, with parts broken away, of a multipole circuit breaker embodying my invention; Fig. 2 is a transverse sectional view on the line 2—2 of Fig. 1; Fig. 3 is a transverse sectional view similar to Fig. 2 but with the circuit breaker closed and part of the toggle broken away; and Fig. 4 is a horizontal sectional view taken approximately on the line 4—4 of Fig. 2.

Improvements may be embodied in any circuit breaker whose action is controlled by a core movable in a dash pot surrounded by a solenoid coil, but for illustrative purposes, I have shown it embodied in a two pole circuit breaker constructed in accordance with the general principles of my patent, No. 2,360,922.

As illustrated in the drawings, each of the pair of circuit breakers comprises an L-shaped bracket **1** of magnetically permeable material having a leg **1***a* fixed to an insulating base **2** and a leg **1***b* extending at right angles thereto. A hollow tube **3** of non-magnetic material is seated in the leg **1***a* and projects from either side thereof with its axis parallel with the leg **1***b*. A soft iron core **4** makes a loose slip fit in the tube **3** and is normally biased by a spring **5** to the inner end of the tube **3**. The valved passage **4'** through the core permits rapid return of an advanced core to its datum position.

The portion of the tube **3** in front of the body of the core **4** is completely filled with a pure paraffin wax having

a sharp melting point above normal ambient temperature and below the thermal deterioration point of the device to be protected or of the elements of the breaker. The end of the tube is tightly sealed by a soft iron plug 7 having an enlarged head 8 forming a magnetic pole. The tube 3 is encircled by a solenoid coil 9 between the washers 10 and 11 adjacent to the leg 1a and head 8 and may have a heating section 9 extending non-inductively around the exposed end of the tube 3 to maintain such end at approximately the same temperature as the tube section within the coil. Each solenoid coil has one end connected to a load terminal 12 and its other end connected with a switch blade 13 which is rockable on a pintle 14 seated in ears 15 of the frame 1 and which are secured to the base 2. Each switch blade is normally biased by a spring 16 away from a contact 17 connected with a line terminal 18.

The switch blades 13 are connected together for simultaneous operation by a shaft 17 journalled in bearings of the switch blades. The shaft 19 is connected with a pivotally mounted operating handle 20 by links 20 and 21 forming a species of over-center toggle which may be held in rigid position by the engagement of a tooth 22 with a flat on the shaft 23 journalled in the link 21 and provided with an arm 25 as shown in Fig. 9 of my Patent No. 2,360,922. The arm 25 has fixed thereto a shaft 26 which lies above bent fingers 27 of tripping armatures 28 complementary to the respective magnetic poles 8. The armatures 28 are pivotally connected with the ears 29 of the frame 1.

If desired the shaft 19 may have a bent finger 30 journalled thereon and engaging a loop 31 of a spring having a loop 32 connected with the link 21. The finger 30 engages and may slide along the bottom of the base 2 so as to bias the link 21 upward and straighten the toggle when the operating handle 20 is rocked.

The breaker illustrated is primarily intended for the protection of a transformer whose secondary windings are connected with the line and load terminals of the switch. The base 2 is so mounted in the transformer tank that at least the end of the tube 3 projecting beyond the coil 9 is immersed in the oil therein. So long as the temperature of the tube section immersed in the oil remains below the melting point of the wax 6, the core 4 is held in its retracted position, and the ampere windings of the coil 9 create insufficient flux to cause the magnetic poles 8 to attract the armatures 28 when the core 4 is in retracted position. The heating of the oil by the overload is partly or wholly neutralized by the cooling system of the transformer and thus kept at a temperature low enough to prevent the deterioration or destruction of the insulation of the transformer windings. The transformer is thus kept in service despite the overload. If, however, there is an overload sufficiently great to cause the transformer core and windings to heat the oil sufficiently high to melt the wax 6, or to cause the coil sections 9 and 9' to heat the wax to a temperature above its melting point, the wax will suddenly melt and the magnetic field of the coil 9 will attract the core 4 into the solenoid coil at a rate determined by the percentage of overload then existing. When the nose of the core approaches or reaches the pole 8, the concentration of magnetic flux will be sufficiently great to attract the armature 28, thereby rocking the finger 27, lifting the rod 26, tilting the shaft 25 and breaking the toggle so as to permit both switch blades 13 to be opened by the springs 16. The breaking of the circuit permits the spring 5 to retract the core 4 to datum position while the molten wax is maintained liquid by the residual heat. If the current has dropped to rated current, the switches may be reclosed and will remain closed so long as there is no excess overload while the transformer oil cools and the wax again solidifies.

Having described my invention, I claim:

1. An electro-magnetic trip mechanism for a circuit breaker comprising an electro-magnet including a dash pot consisting of a magnetically impermeable hollow tube having a magnetically permeable pole piece at an end thereof, a magnetically permeable core movable rectilinearly in said tube, a solenoid coil wound on said tube for the passage of current to generate flux tending to move said core, a solid thermotropic substance in said tube preventing rectilinear movement of said core at normal operating temperatures of said circuit breaker and said substance liquefying suddenly at temperatures above the normal operating temperature of said circuit breaker and thereby forming a dash pot liquid permitting but retarding the movement of said core toward said pole piece, and an armature in the field of said pole piece and attracted more strongly thereby as said core approaches said pole piece.

2. An electro-magnetic trip mechanism for a circuit breaker and comprising a dash pot including a hollow non-magnetic tube having a magnetically permeable core movable rectilinearly therein, a magnetically permeable pole piece at one end of said tube, a solenoid coil wound on said tube and generating flux tending to move said core toward said pole piece upon the passage of current through said coil, and a solid thermotropic substance in said tube normally preventing movement of said core responsively to magnetic flux, said substance having a sharp melting point within a range not appreciably exceeding 2 degrees centigrade and forming when melted a liquid permitting but retarding the movement of said core toward said pole piece by magnetic flux.

3. In a circuit breaker, a tube of magnetically impermeable material having a pole piece at one end thereof, a solenoid coil wound on said tube, a magnetically permeable core in said tube, said coil creating a flux tending to move said core toward said pole piece upon the passage of current through said coil, said armature being positioned in the field of said pole piece and attracted more strongly thereby as the core approaches said pole piece, and a solid wax between said core and pole piece and preventing movement of said core under normal temperature conditions of said circuit breaker notwithstanding the flow of abnormal current through said coil, said substance having a sharp melting point above the normal operating temperature of said circuit breaker and forming when melted a liquid permitting but continuously retarding the movement of said core throughout the length of said tube by flux generated by the flow of current through said coil.

4. A circuit breaker comprising a tube having a pole piece at an end thereof complementary to said armature, said armature being in the field of said pole piece, said tube containing a magnetically permeable core movable rectilinearly toward said pole piece to increase the attraction thereof for said armature, a liquefying wax between said pole piece and core, and a coil surrounding said tube and generating flux tending to move said core toward said pole piece upon the passage of current through said coil, said wax being solid and preventing movement of said core by flux to said pole piece under normal temperature operating conditions of said circuit breaker and said wax having a sharp melting point and being liquefiable by heat generated by an overload current passing through said circuit breaker and coil, said liquefied wax acting as a fluid in a dash pot to permit but retard the movement of said core toward said pole piece by flux aforesaid.

5. An electro-magnetic trip mechanism for a circuit breaker and comprising a tube having a pole piece at an end thereof, an armature complementary to said pole piece, a coil encircling the exterior of said tube, and a magnetically permeable core and a thermotropic substance of sharp melting point substantially filling said tube, said substance being solid and preventing movement of said core under normal operating conditions of said circuit breaker, and said substance being suddenly liquefiable by abnormal heat and permitting movement of said core in said tube but interposing a continuous retardation to the movement of said core throughout the length of said tube by flux generated by the flow of current through said coil.

6. An electro-magnetic trip mechanism for a circuit breaker and comprising a tube having a pole piece forming a closure for an end thereof, a fulcrumed armature complementary to said pole piece and movable exteriorly of said tube toward and from the outer surface of said pole piece, a magnetically permeable core in said tube and having a nose of smaller diameter than the remainder of said core movable into contact with the inner surface of said pole piece, a coil forming ampere turns around said tube from said pole piece to a point intermediate the ends of said core when the latter is fully retracted, a sharp melting point wax in said tube and substantially filling all of the otherwise unoccupied space therein, said substance forming a solid block preventing movement of said core at normal operating temperature of said circuit breaker and being suddenly liquefiable by

abnormal heat to permit movement of said core but interposing continuous retardation to the movement of said core toward said pole piece when said circuit breaker is subjected to abnormal temperatures.

7. An electro-magnetic trip mechanism for a circuit breaker and comprising a tube having a pole piece forming a closure for an end thereof, an armature exterior to said tube and complementary to said pole piece, a magnetically permeable core, a sharp melting point paraffin wax substantially filling said tube, a coil forming ampere turns around the exterior of a portion of said tube adjacent to said pole piece, and a non-inductive heating element connected with said coil for heating the end portion of said tube beyond said coil.

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